Observe the movement of the ink-
pen barrel as your teacher places
t in the liquid. Record your
bservation in your log.

I will now make an ink-pen barrel
it in liquid.

the ink-pen barrel floats.

a) Before you begin, predict what you think will happen in each part of this step. Give a reason for your prediction.

Chem Talk

DENSITY

Density as a Property of Matter

If you were to compare a 1 cm^3 cube of iron to a 1 cm^3 cube of wood, you would probably say that the iron is "heavier." However, if you compared a tree trunk to iron shavings, the tree trunk is obviously heavier. As you discovered in this activity, a "fair" comparison of the "heaviness" of two materials is a comparison of their densities. **Density** is the mass per unit volume of a material. In this activity you measured the density of water and other liquids. You found that each sample of the same liquid had the same density and each different liquid had its own characteristic density. You also found that each solid material you investigated had its own characteristic density. Density can be expressed in grams per milliliter (g/mL) or grams per cubic centimeter (g/cm^3). The table on the next page shows the densities of some common liquids and solids.

You used the slope of the mass versus volume graph of a material to calculate density. You also calculated density using the equation:

$$\text{Density } (D) = \frac{\text{Mass } (m)}{\text{Volume } (V)}$$

Density and Flotation

In this activity you further observed that materials with a greater density than a given liquid will sink, and materials with less density than a given liquid will float. In the column of colored liquids, the liquid with the highest density was on the bottom, and the liquid with the lowest density was on the top. The ink-pen barrel sank in ethanol and floated in water. When you added ethanol to the water you created just the right density to have the ink-pen barrel float within the liquid. This position of floating is where the density of the ink-pen barrel is equal to the density of the ethanol/water. The ink-pen barrel "found" the place where the density of the liquid was identical to the density of the ink-pen barrel.

Approximate Densities of Some Common Liquids and Solids

Material	Density (g/cm^3)
wood (balsa)	0.12
wood (birch)	0.66
gasoline	0.69
isopropanol	0.79
vegetable oil	0.92
distilled water	1.00
glycerol	1.26
magnesium	1.70
aluminum	2.70
iron	7.90
copper	8.90
nickel	8.90
silver	10.50
mercury	13.50
gold	19.30

The most famous story about density is when Archimedes jumped out of the bath, ran through the town naked, and shouted "Eureka!" As the story supposedly goes, Archimedes was asked by the king to determine if his crown was solid gold. Archimedes knew the density of gold. He also knew that he could correctly determine if the crown were gold if he knew the density of the crown. The mass of the king's crown was easy to measure. The volume posed a real problem because it had such an unusual shape, and of course the king did not want his crown altered. When Archimedes submerged himself in the bathtub, he realized that the displacement of water would provide him with the volume. *Eureka* is Greek for "I found it."

MAKING MEASUREMENTS AND USING THE MEASUREMENTS TO MAKE CALCULATIONS

Uncertainty of Measurements

Every measurement that you make involves some uncertainty. When you measured the volume of water using a graduated cylinder, you used the division of units marked on the side of the cylinder to make your measurements. Suppose the smallest precision division marked on the graduated cylinder was a milliliter. This means that you can estimate the measure to the nearest tenth of a milliliter, because you can see if the level of the water is at, above, or below the mark. When you record your measurement of volume, you can record it as 10.0 mL, because you can see whether the level of the water is at, above, or below the 10 mL mark.

Remember to always look at the instrument that you are using and determine the smallest precision mark it has. When you make your measurement using the instrument you can only estimate to the next place. If you are using an electric balance to measure mass, it will do the estimating work for you. Most school balances will measure to the tenth, or the hundredth of a gram.

Calculations

When you perform calculations using the measurements that you made in an investigation, you need to express the result of your calculations in a way that makes sense of the certainty of the measurements you made. For example, when calculating the density of a 10.1 mL sample of liquid with a mass of 9.8 g, you may obtain a value of 0.9702770... g/mL using a calculator. This value does not seem reasonable when considering limitations of your measurements.

There are rules that you can use when making your calculations:

Adding and Subtracting

When adding or subtracting numbers, arrange the numbers in columnar form lining up the decimal points. Retain no column that is to the right of a column containing a doubtful digit.

Multiplying and Dividing

In multiplication and division, the result should have no more significant digits than the factor having the fewest number of significant digits. To determine how many digits are significant, count all the digits excluding zeroes at the beginning or end (e.g., 0.00326 and 71800 each have 3 significant digits). (Exception: a zero at the end of a number is significant if the number contains a decimal point — for example, 0.00326 has 3 significant figures, 0.003260 has 4, and 3260 has 3.)

Reflecting on the Activity and the Challenge

In this activity, you discovered that the

suspended. You can make use of t
challenge. For